KING COUNTY

ROAD RIGHT-OF-WAY DRAINAGE TRUNK LINE ASSESSMENT

FINAL REPORT

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Prepared For:

King County
Department of
Natural Resources and Parks
Water and Land Resources Division
and
Department of Transportation
Road Services Division

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Report

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From: HDR
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Executive Summary

This executive summary provides a brief introduction of the King County Right-of-Way Drainage Condition Assessment project and the problem being considered, discusses the methodology used to address the problem, and lists the principal conclusions and recommendations.

Introduction

The King County (County) Road Services Division (Roads) manages the majority of the drainage within the right-of-way (ROW) in unincorporated King County. A large portion of this drainage system is at or nearing the end of its useful life. The largest and most costly components of this aging system are pipe systems and metal culverts 24-inch or larger in diameter, referred to in this study as the regional trunk drainage system.

County Roads has an on-going effort to map and inventory the trunk drainage system. Drainage features are assigned an asset identification number and components of each asset are inventoried. This data is stored in the County's Stormwater Geodatabase (SWGDB), which will be used to inform asset management decisions for managing the system cost-effectively within the County's selected risk tolerance.

The County Council has requested a report from County staff that will describe the location and condition of the drainage system within major road ROWs in unincorporated King County, the estimated accuracy of the resultant database, an analysis of the data to assess risks and impacts, and a prioritized program for maintenance, including replacement schedule and costs. The County Council has also called for a second report that will include, among other items, a plan for investments in drainage projects.

Roads and the Water and Land Resources Division (WLRD) have formed a partnership to respond to the County Council and to administer this project. WLRD retained HDR as the Prime Consultant to lead the project, which entails asset inventory validation, data collection, and mapping and recommending the level of service and asset management strategies for the regional drainage system. The results of this project will be used by County staff to complete their reports to the County Council.

The work performed under this contract is organized into two phases, as follows:

- **Phase 1** included inspecting regional trunk drainage assets that were pre-selected for inspection by the County, assessing the County's current Business Risk Exposure (BRE), and recommending system maintenance and renewal needs to manage the identified risks.
- **Phase 2** included updated risk assessment and risk mitigation planning; cost estimates for recommended near-term actions on the assets inspected in Phase 1; and analysis and comparison of alternative levels of service and their relative risks and financial impacts over the next 100 years.

Methodologies

The methodologies for this work included the following main components:

- Asset inspections;
- Assessment of Business Risk Exposure (BRE);
- Predicting unmapped system assets;
- Extrapolating available asset risk information to mapped and unmapped portions of the system;
- Rating confidence in the available BRE risk information;
- Developing near-term risk mitigation actions and cost estimates; and
- Identifying, analyzing, and comparing Level of Service (LOS) alternatives and their long-term cost of ownership.

King County selected a sub-set of assets that were identified as potentially high risk to verify, update, and collect attribute and positional location and structural condition ratings using the County's Environmental Systems Research Institute (Esri)-compatible, mobile collection platform. Asset data collected in the field was stored in the County's SWGDB and used to support analysis and development of asset management recommendations.

BRE risk score is a calculated value that represents the County's relative overall assumed risk of the failure of an asset or asset group. Values range between 1 and 100, with higher values indicating increasing levels of risk. The BRE scoring results are used to help prioritize investments in inspection, maintenance, rehabilitation, and replacement activities, informing the prioritization of near-term actions needed to mitigate asset risks and/or help meet level of service goals. BRE assessment entailed calculating Probability of Failure (POF), Consequence of Failure (COF), and BRE risk scores for each asset using a modified version of the County's guidelines (NDc King County).

Predicting unmapped assets was necessary because portions of the County-owned regional trunk drainage system assets are currently unmapped and therefore do not exist within the SWGDB. While the unmapped assets have unknown locations, attribute information, and condition, their management is expected to affect strategic and budgetary planning and needed to be factored into the analysis.

The available asset risk information for the Phase 1 inspected assets was used to extrapolate risk information to the assets that were not inspected. This extrapolation was done for both mapped and unmapped assets that were not inspected. Significantly more information was available to support the analysis for mapped assets as compared to the unmapped assets, such as Geographic Information System (GIS) data that could be used to calculate the COF factors directly. Thus, the risk extrapolation methodologies used was tailored for the mapped and unmapped asset groups accordingly.

Confidence ratings provide an asset-by-asset assessment of the quantity and quality of the data used to calculate POF and COF scores. The confidence ratings use percentages to allow for a relative comparison of the actions taken to establish asset condition or assign attribute information (e.g. depth, diameter, etc.), with higher values indicating higher confidence. This method is adapted from the Water Environment Research Foundation (WERF) (2016). The asset-level confidence rating information can be used by Roads on a planning level to assess how reliable existing information might be and how it may be improved over time. As the asset management program develops, Roads can use a similar methodology to determine when the available information is of sufficient quality to support asset management decision-making on a project level, or when additional information is needed, based on procedures and tolerances for data quality.

Near-term risk mitigation actions were defined in coordination with County staff. The actions were assigned to the inspected assets based on their calculated BRE/POF scores, using a decision logic model in Excel. To mitigate the identified critical risks, immediate corrective actions were recommended. To mitigate the identified high, medium, and low risks, recommendations were provided to conduct specified actions within the next 10 years.

Four (4) LOS alternatives were developed in coordination with County staff and were modeled to assess and compare their long-term (100-year) cost of ownership. One alternative represents a regime of responding to emergencies and running assets to failure. The remaining 3 alternatives represent various levels of risk tolerance. Cost of ownership calculations were performed in an Excel model.

Conclusions and Next Steps

Key conclusions from the results of the analysis and recommended next steps for sustained programmatic asset management are provided below.

Asset Inspections

This study conducted asset inspections to validate, update, and collect attribute data for high priority portions of the regional trunk drainage system within major road right-of-way areas in unincorporated King County. The data collected were used to support risk assessment and development and prioritization of risk mitigation actions.

The County pre-selected the assets to be inspected using an age-based structural condition rating approach and best available information at the time. A total of 1,266 assets were prioritized for inspection in Phase 1 of this study. During the course of inspecting these prioritized assets, some additional assets were found and some assets were retired (i.e., no longer in use). A net total of 1,174 assets that are active (i.e., not retired) and are 24-inch diameter or greater were inspected in Phase 1.

Predicted Unmapped Assets

The Phase 1 inspection data was used to predict unmapped (i.e., unknown) 24-inch or larger assets in the unincorporated roadway right-of-way areas. A total of 1,627 additional unmapped assets (termed Phase 2 unmapped assets) were predicted to potentially exist, representing an approximate 38% increase in the number of 24-inch or larger roadway right-of-way assets currently included in the County's SWGDB.

Business Risk Exposure Assessment

BRE risk scores were calculated for 897 of the inspected assets using a modified version of the County's approach to structural condition rating (NDb King County) and probability of failure calculation (NDc King County). The remaining 277 inspected assets (1,174 – 897) were not analyzed because they lacked sufficient condition assessment data and/or photographs to support the calculations. The assets lacking information were generally inaccessible or could not be photographed during the Phase 1 inspections. The assessment identified 33 critical risk assets because they were either failing or at risk of imminent failure and have a high consequence of failure.

The calculated BRE risk scores for these 897 inspected assets were used to extrapolate risk scores for 5,065 uninspected assets (3,438 mapped and 1,627 unmapped assets, see Table ES-1). From this extrapolation, a total of 206 additional critical risk assets (104 mapped and 102 unmapped critical risk assets) were estimated to potentially exist within the regional trunk drainage system.

Table ES-1 summarizes the number of assets for which BRE risk assessment was performed, including the Phase 1 inspected (mapped) assets and Phase 2 assets that were not inspected (mapped and unmapped assets).

Table ES-1. Summary of BRE Risk Score Calculations for Mapped and Unmapped Assets, Inspected and Not Inspected

	Phase 1 Inspected	Phase 2 Not Inspected		
Component	**Mapped Assets**	**Mapped Assets**	**Unmapped Assets**	**Total**
Pipe/Culvert	482	2,490	1,040	**4,012**
Manhole	20	53	36	**109**
Structure with sump	355	848	531	**1,734**
Structure without Sump	40	47	20	**107**
Total	**897**	**3,438**	**1,627**	**5,962**

Near-Term Risk Mitigation for Assets Inspected in Phase 1

The discussion in this section applies only to the assets inspected in Phase 1, as explained in the previous section titled Asset Inspections. Near-term risk mitigation actions and costs were not estimated for the uninspected assets (see Table ES-1 for summary of inspected and uninspected assets).

For the 33 critical risk assets identified through the Phase 1 asset inspections, immediate preservation action is recommended due to the critical nature of their observed condition and calculated POF/COF scores. These immediate actions are estimated to cost approximately $6,460,000. Failure to implement the recommendations immediately would increase the likelihood of emergency repairs being needed.

For the 864 high, medium, and low risk assets identified through the asset inspections (897-33), on-going mapping, inventory, condition assessment, inspection, and maintenance actions and one-time preservation rehabilitation and replacement should be implemented within the next 10 years. The estimated cost for implementing the 10-year risk mitigation actions for assets inspected in Phase 1 is estimated to be $19,280,000. Thus, the total estimated near-term costs, including the immediate and 10-year recommended risk mitigation actions for the Phase 1 inspected assets (897 assets) is estimated to be $25,740,000.

As discussed above, the cost figures presented in this section do not include the Phase 2 uninspected assets (mapped nor unmapped), nor do they include other unknown assets that may be addressed by the County later. While critical risk asset numbers were estimated for the Phase 2 uninspected assets, the actual locations and numbers of these critical risks is unknown. Therefore, the near-term costs to address the true number of critical risks for all regional trunk drainage assets is unknown, and is expected to be higher than the cost figures presented above for the Phase 1 inspected assets only.

The decision logic model used to assign risk mitigation actions is useful to support strategic business planning efforts. However, it does not include the detailed decision-making parameters that should be applied on a project-by-project basis. For instance, though preservation rehabilitation was assumed to be feasible and cost-effective for a portion of the assets, further assessment is required to determine whether rehabilitation is feasible for specific assets and, if so, the most appropriate type of rehabilitation to be used.

Therefore, more detailed analysis will be needed to support development and prioritization of specific projects (or packages of projects) to be implemented by Roads. The near-term risk mitigation actions recommended herein should be reviewed, updated as needed, and factored into other project identification and prioritization techniques used by Roads, such as business case evaluation or options analysis.

Confidence Ratings

Confidence in the quantity and quality of the data used to calculate POF, COF, and BRE risk scores was assessed using an approach adapted from the Water Environment Research Foundation (WERF) Capital Investment Validation and Prioritization Tool (2016). The approach was modified to reflect County guidelines for calculating POF, COF, and BRE risk scores.

As may be expected, the Phase 1 inspected assets have the highest confidence rating, because their locations and attribute information are known and most assets were visually inspected in Phase 1. Confidence in the unmapped assets is very low due to the lack of information available regarding their location and attributes. While GIS-based prediction techniques were implemented using best available information, there was a limited available database upon which to base or validate the model.

Comparing POF and COF confidence ratings, the values are generally higher for COF than for POF scores. This is because POF calculation requires extrapolating condition information for the majority of the assets that were not inspected. COF calculation, on the other hand, can be calculated for mapped assets largely on available information (i.e., location in sensitive areas and floodplains, proximity to roadways, etc.), without the need to visit the assets.

The confidence ratings developed can be used by County staff to assess whether sufficient information is available to support decision-making for individual assets or whether additional data is needed. This assessment should be based on County procedures and tolerances for quantity and quality of data needed to base such decisions.

Level of Service Analysis

The LOS analysis is similar to the near-term analysis (discussed above), but is different in that this analysis evaluates the cost of ownership for all assets (See Table ES-1) over a long-term (100-year) period, for 4 various service level alternatives. The 4 alternatives, labeled LOS A through D, were developed in coordination with County staff. LOS D represents a scenario in which assets are run to failure, emergency response is provided, and backlog continues to grow over time. LOS C focuses on managing critical risk assets and, like LOS D, allows backlog to continue to grow over time. LOS B eliminates backlog in 25 years and prevents new backlog from accumulating. LOS A tolerates the least amount of system risk, eliminating the current backlog immediately and preventing new backlog from accumulating.

A 100-year cost of ownership model was developed in Excel to analyze and compare the cost of ownership of the alternatives. The model simulates asset deterioration, assigns risk mitigation actions, and calculates costs over the 100-year period for the Phase 1 inspected and Phase 2 uninspected (mapped and unmapped) assets. The model does not simulate the social and environmental costs of implementing or not implementing actions in the given timeframes, but recommendations to consider these additional costs are provided in Section 5.

Reported costs represent Class 5 estimates as defined by AACE International (previously known as the Association for the Advancement of Cost Estimating International or AACEI) with an expected accuracy range of -50% to +100%. All reported costs could vary within those ranges.

The modeled net present value costs were $750 million for LOS A, $667 million for LOS B, $815 million for LOS C, and $829 million for LOS D. Although the modeled net present value for LOS B was the lowest, the modeled total real cost of over $9 billion is more than twice as high as LOS C and D. This is because the net present value cost calculations use a discount rate of 5.5% to account for the time value of money. The discount rate used significantly dampens the effect of large capital expenditures that would be needed late in the 100-year simulation period for LOS A and LOS B, diminishing the impact on the calculated net present

value. The cost comparisons also reflect the fact that LOS A and B do not require emergency repairs.

The following items should be considered by the County when reviewing and comparing the LOS alternatives presented in this report:

- Revisit the assumption that running assets to failure (i.e. POF = 10) will significantly increase preservation costs. Currently, it is assumed that replacing or rehabilitating an asset at the time of failure will result in an emergency preservation cost premium of 50%, as compared to the cost of preserving the assets prior to failure (i.e., non-emergency mode). The 50% premium cost assumption for emergency preservation has not been verified due to lack of available historical County costs. It should be noted however, that social, environmental, and other ancillary costs are certainly higher when an asset is allowed to fail. Because these costs are difficult to quantify, they are not included in the cost of ownership produced in this report. They should continue to be considered, and estimated when possible, at both the planning-level and during CIP prioritization.
- As the County moves from high-level planning and risk analysis to budget and financial planning, real costs should be considered over net present value (NPV). It should also be noted that predictions and estimates far into the future are more variable than those in the near-term.

Recommendations from the LOS alternatives analysis should be implemented in coordination with Roads' Strategic Plan for Road Services (King County 2014). The Strategic Plan for Road Services establishes the goals for road services delivery and the policies and guidelines for managing the County's roadway system.

Recommended Next Steps for County Implementation

The following next steps are recommended for implementation by the County for sustaining and expanding the asset management program

I. **Implement recommended near-term risk mitigation actions** – These costs are included in the recommended near-term risk mitigation action cost estimates.

II. **Conduct on-going asset inspections** – These costs are included in the LOS alternatives analysis cost estimates.

III. **Review/revise POF to include failure factors beyond mortality (e.g. capacity, financial efficiency, maintainability)** – These costs are not included in the cost estimates presented in this report.

IV. **Review and revise COF factors as appropriate based on selected LOS alternative** – These costs are not included in the cost estimates presented in this report.

V. **Validate unmapped asset inventory** – These costs are not included in the cost estimates presented in this report.

VI. **Validate BRE risk scores for uninspected assets** – These costs are not included in the cost estimates presented in this report.

VII. **Implement enhanced condition assessment program to inspect assets that could not be entirely seen during Phase 1 inspection and/or assets that were not pre-prioritized by the County for Phase 1 inspection** – These costs are included in the recommended near-term risk mitigation action costs and the recommended long-term (i.e., LOS alternatives analysis costs).

VIII. **Conduct hotspot mapping to identify problem areas in the system** – These costs are not included in the recommended near-term risk mitigation action costs.

IX. **Develop and implement a formal CIP prioritization process** – These costs are not included in the cost estimates presented in this report.

X. **Formalize the Stormwater Asset Management Program** – These costs are not included in the cost estimates presented in this report.

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